Collaborative Medical Visualization: Issues and Ideas

Chris Johnson

Scientific Computing and Imaging Institute

School of Computing

University of Utah

Collaborative Medicine

The need for collaborative visualization in medicine comes from a variety of problems within healthcare
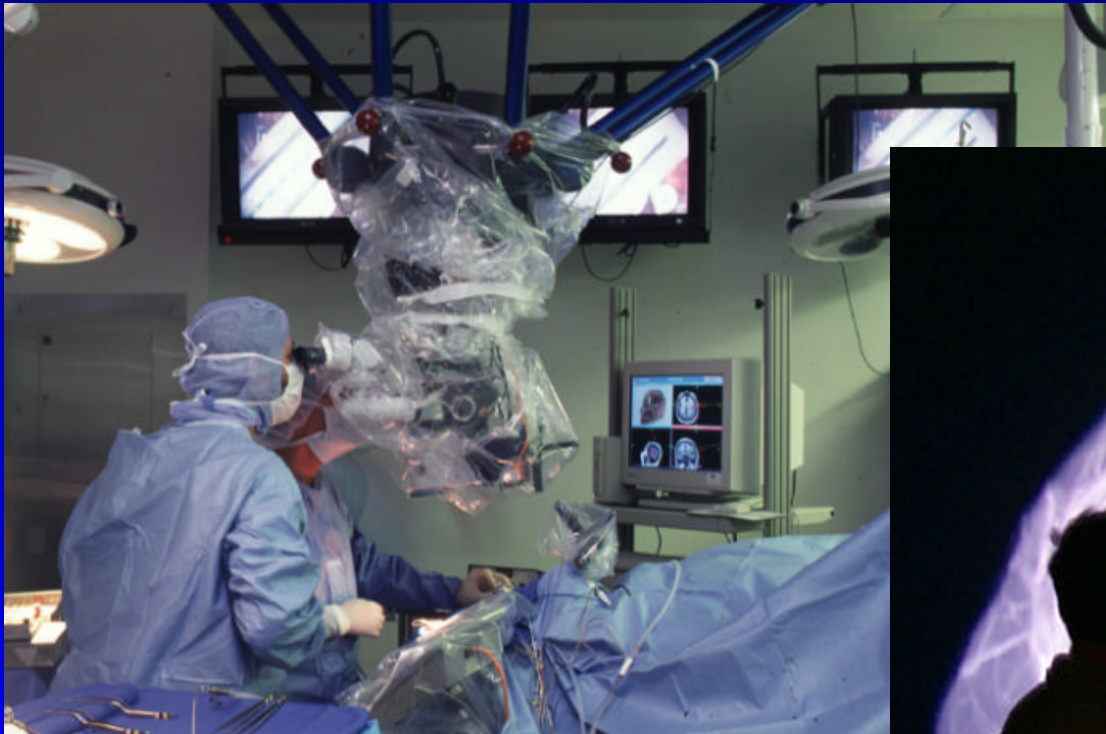
Collaborative visualization is much more than telemedical applications!

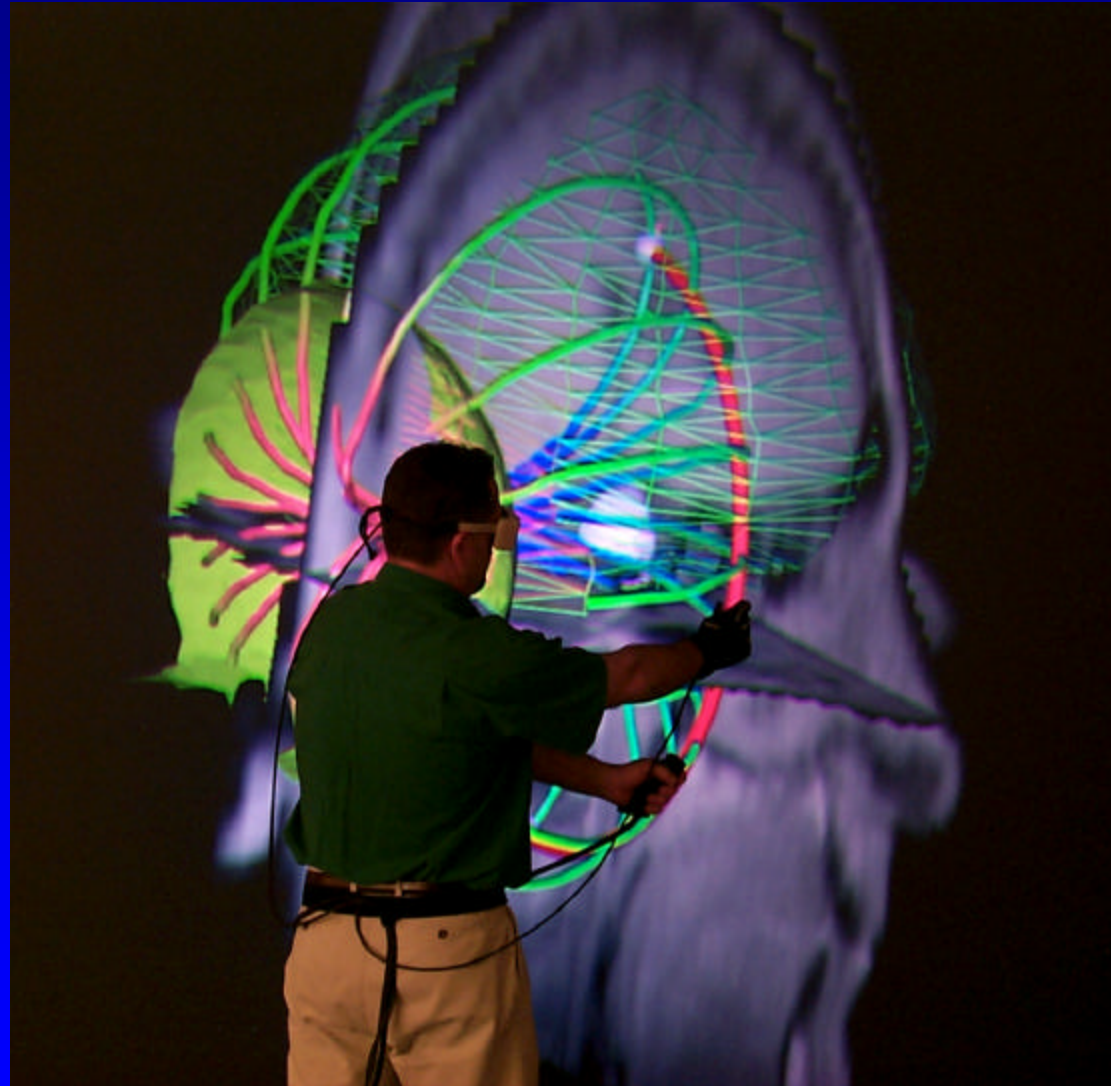Really about interactive sharing of information and images
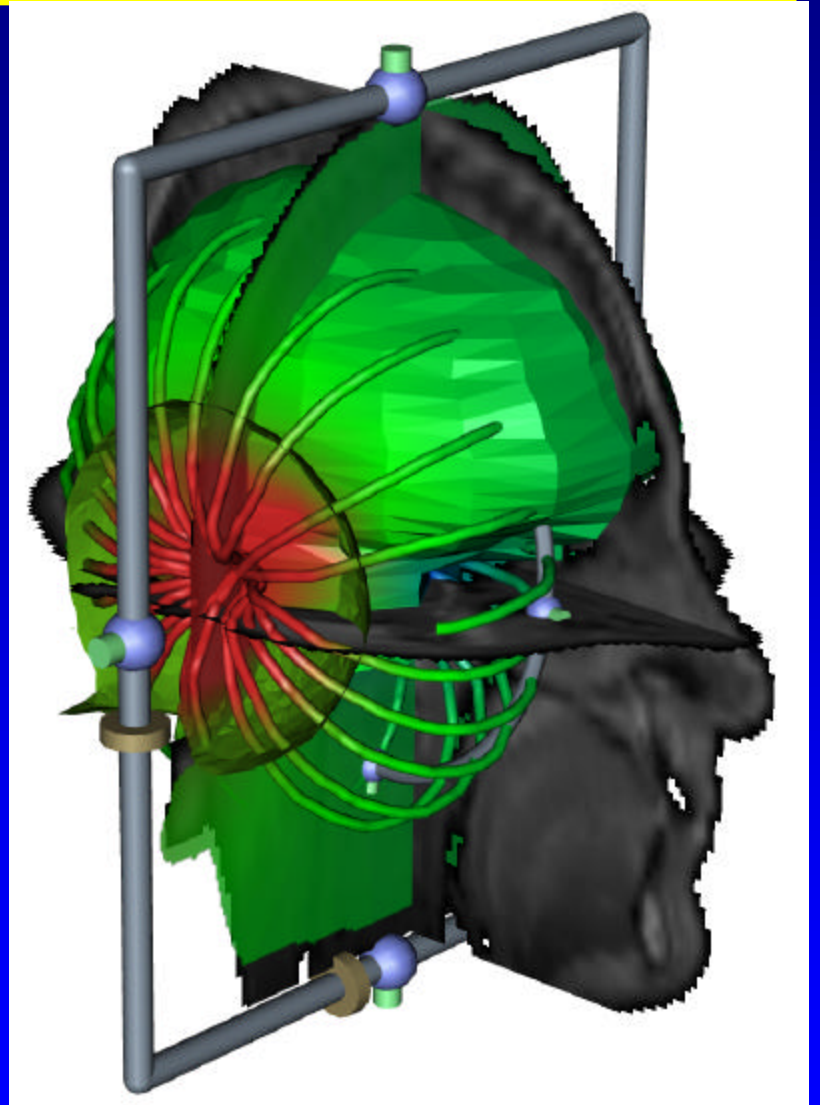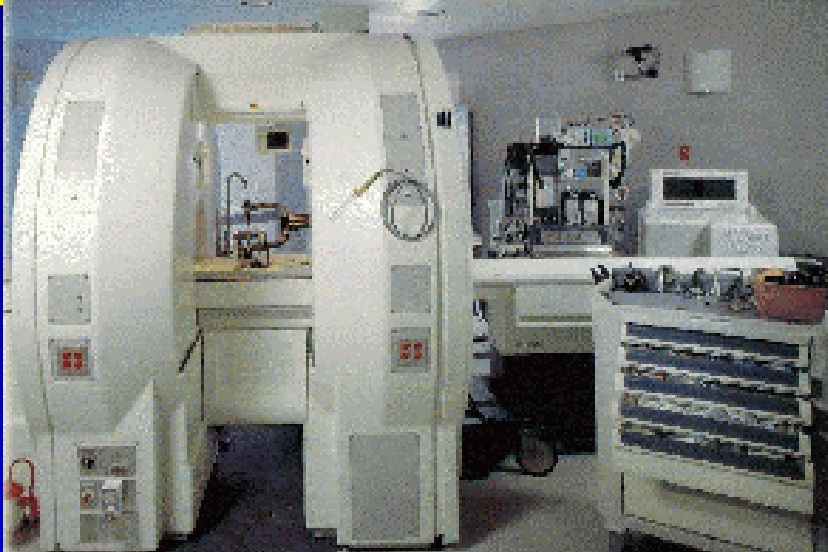
Immersive Environments

Immersive Environment

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Time-critical: Neurosurgery

Harvard & Brigham Women's Hospital

Device Design: Defibrillation

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Protecting Cheney's heart

After undergoing heart tests, Vice President Dick Cheney was given a "smart" pacemaker.

Heart test: Electrophysiology study (EPS)

Electrode inserted into heart to measure how it beats under stress

1 **Thin probe** threaded up vein to heart

2 **Heart stimulated** with electric signals to vary its speed

3 **If irregular beat occurs,** doctor gives different medicines to see which corrects beat best

Test lasts 2-4 hours

Treatment: Implantable cardioverter defibrillator (ICD)

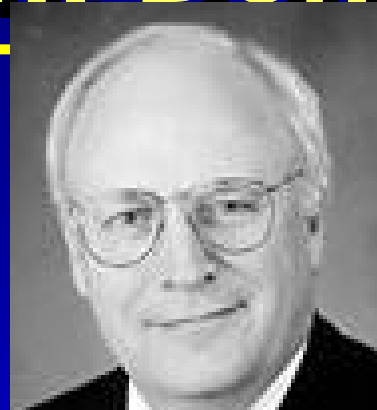Pacemaker that constantly monitors heartbeat and interrupts dangerous rhythm automatically

How it works
- Detects irregular or racing heartbeat
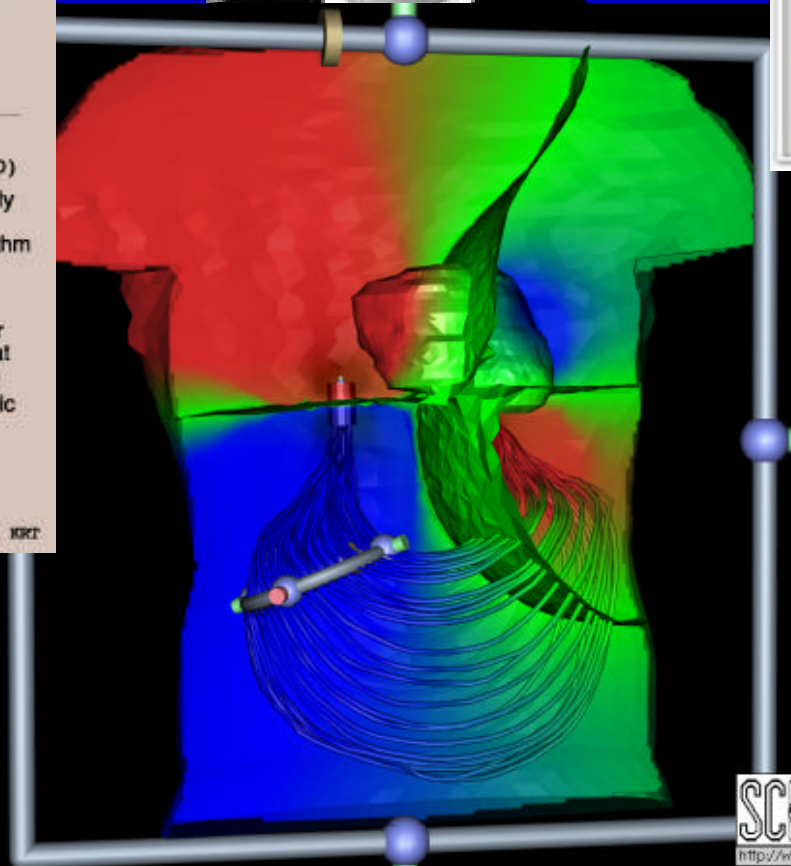- Stops abnormal rhythm with electric pulses or shock
- Implanted under skin on chest

Heart
Vein
Catheter

© 2001 KRT
SOURCE: AP, Torrance (Calif.) Memorial Medical Center
Graphic/LEE HULTENG

© 2001 KRT

"Traditional" Motivation

Expert opinion can be made available at more times and places

Medical professionals (and others) who live in rural areas are less isolated

Workloads can be more effectively balanced (thus lower cost)

Additional Motivation

Accessibility to more (and hopefully better) information

Leverage additional expertise (often outside your area)

Better healthcare

Issues (short list)

Level of Security

Bandwidth

Latency

Reliability

Accessibility

Supported Protocols

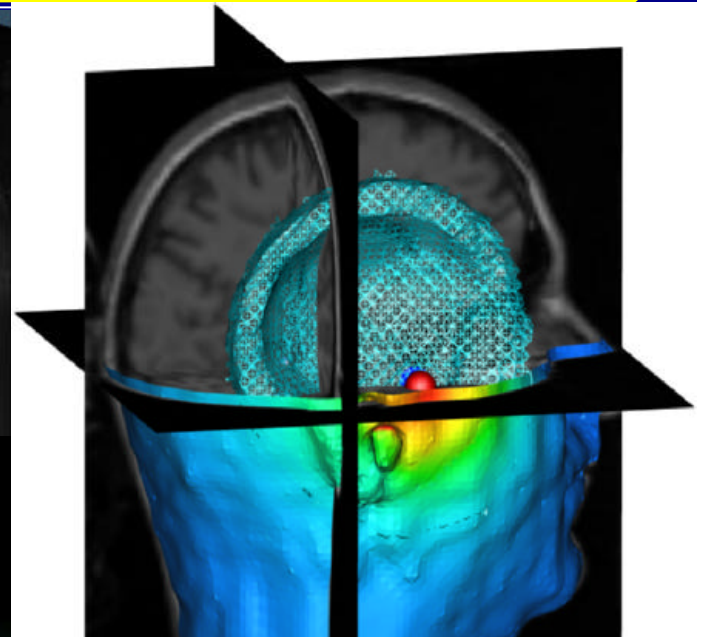Sociology

Interactive Large-Scale Visualization
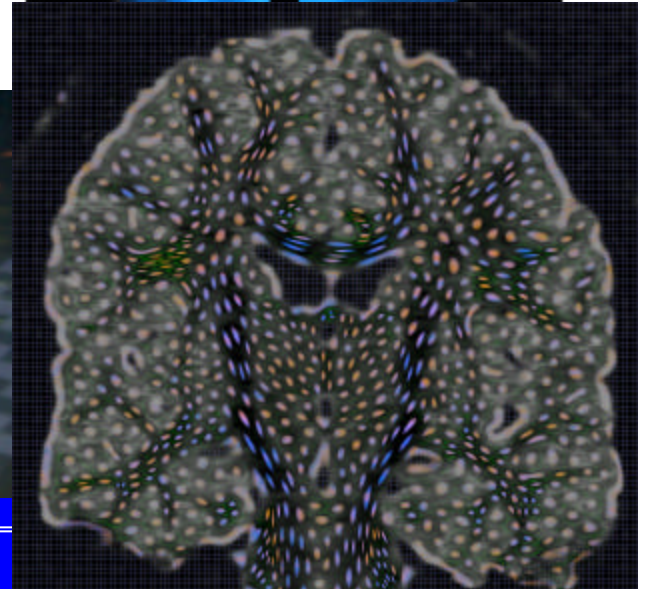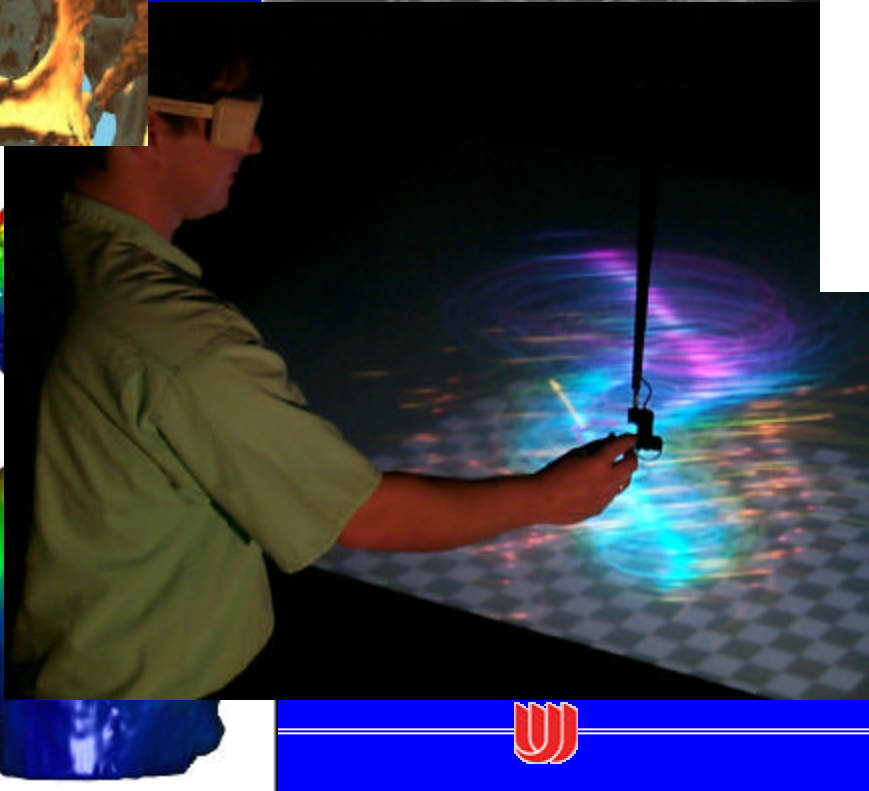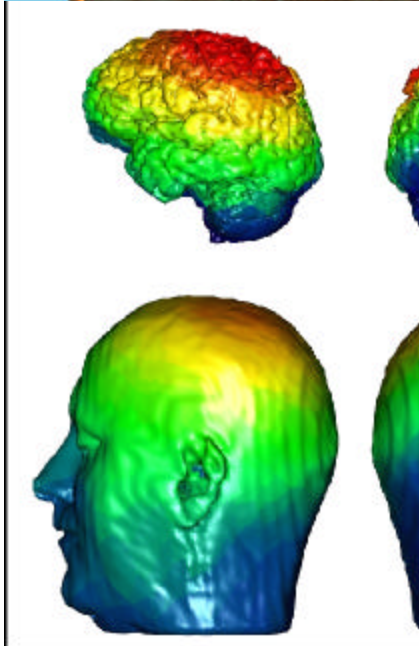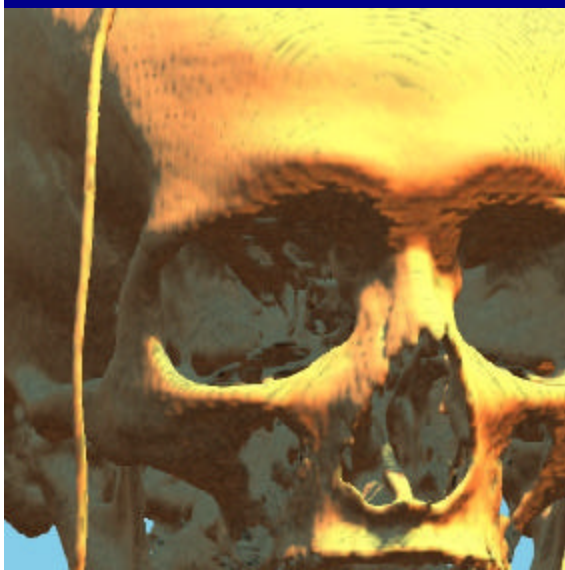
Image Resolution

64x64x64
= 512K

128x128x128
= 4M

256x256x256
= 32M
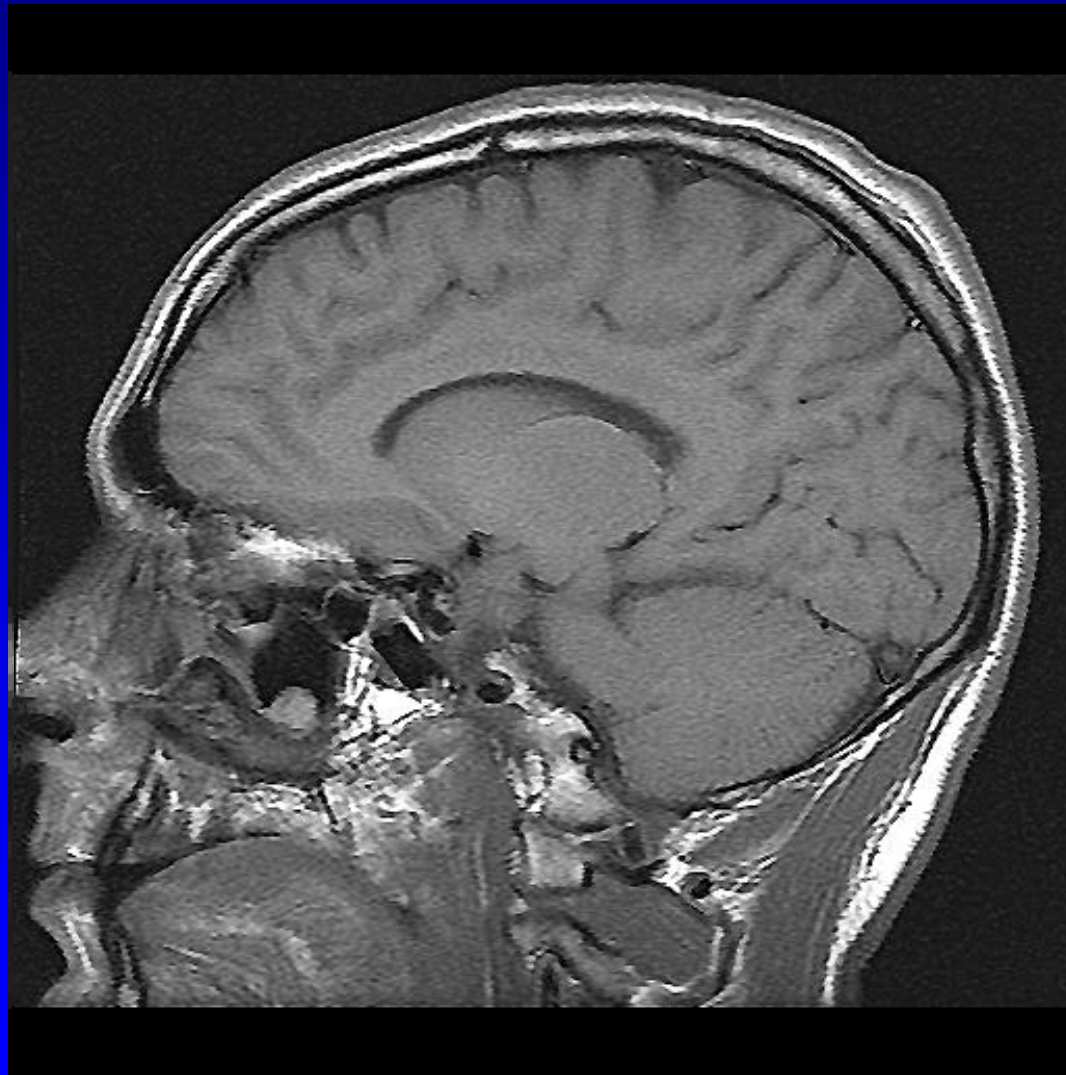
512x512x512
= 260M

High Resolution Rendering
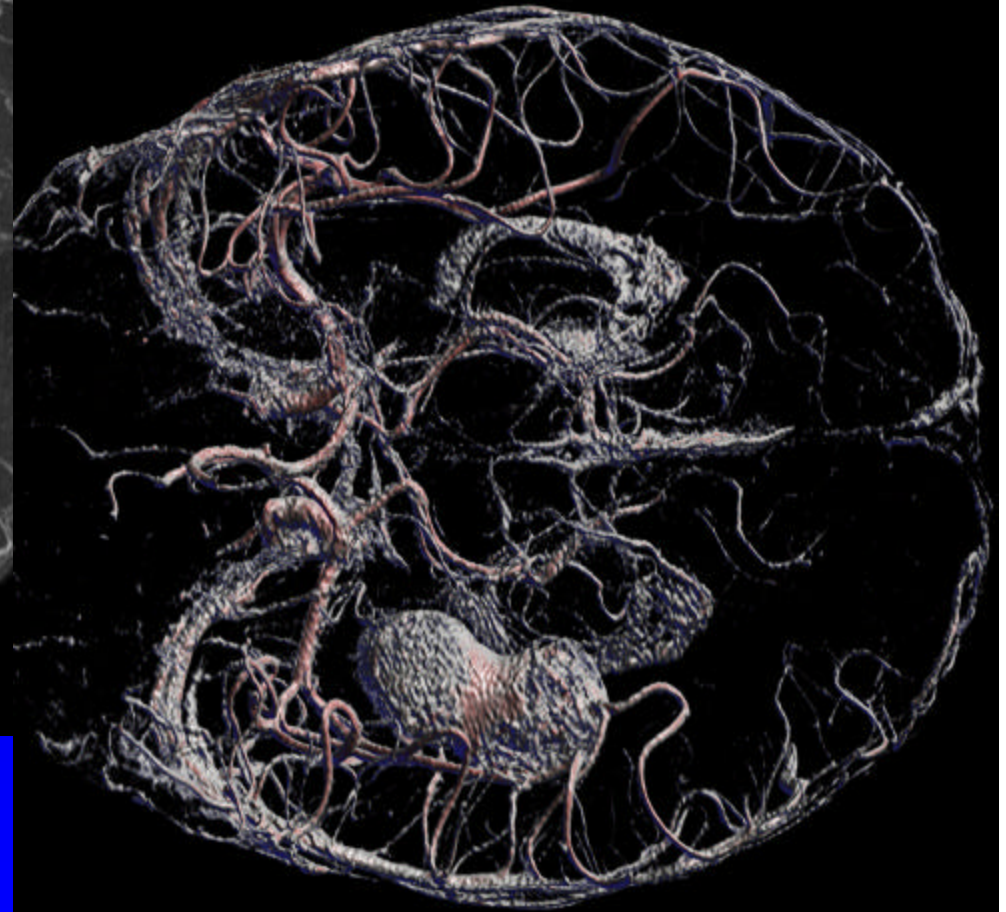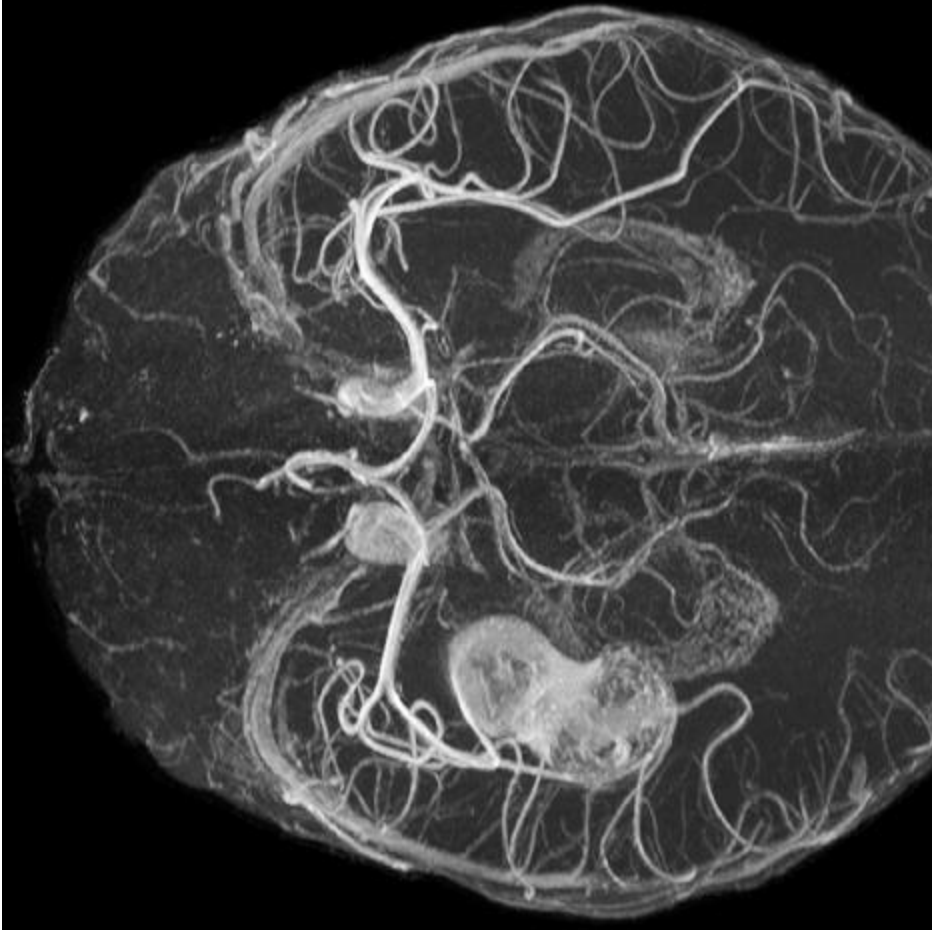
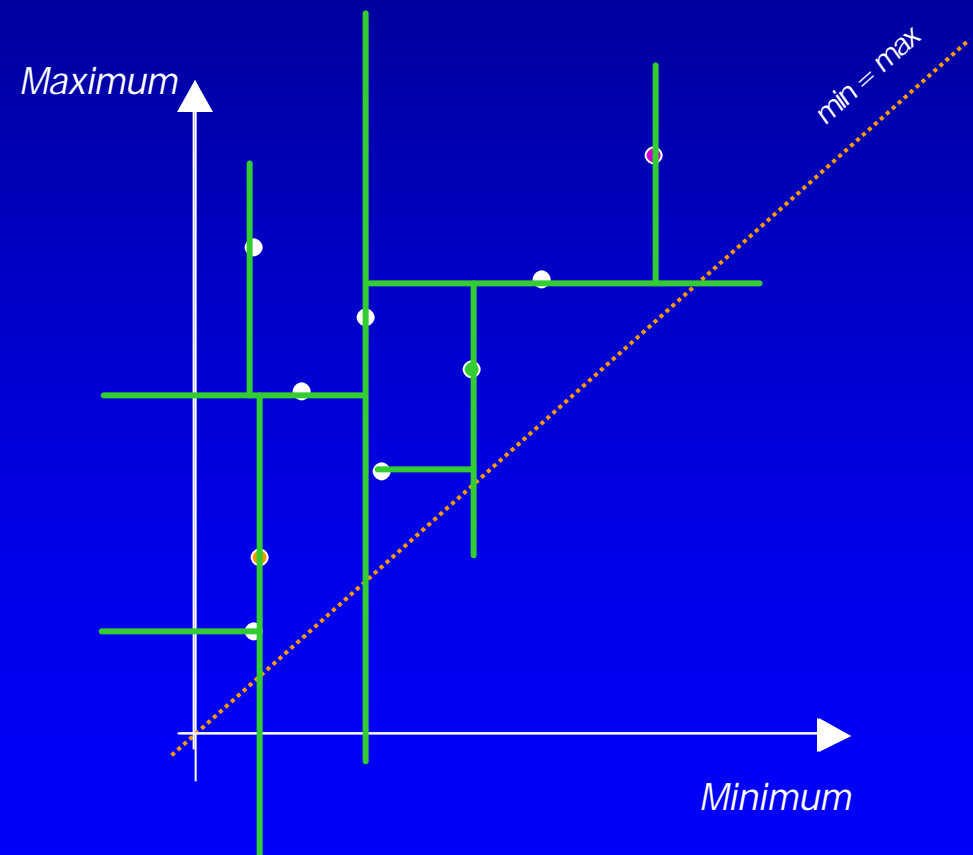# Isosurface Extraction

Marching Cubes

Octree

Extrema Graphs

Sweeping Simplices

The Span Space

- **NOISE: O($\ddot{O}$n+k)**

Livnat, Shen, Johnson

Isosurface Extraction

Still not good enough.

So, how can we do better than optimal?

The Visualization Pipeline

Reduce the amount of data

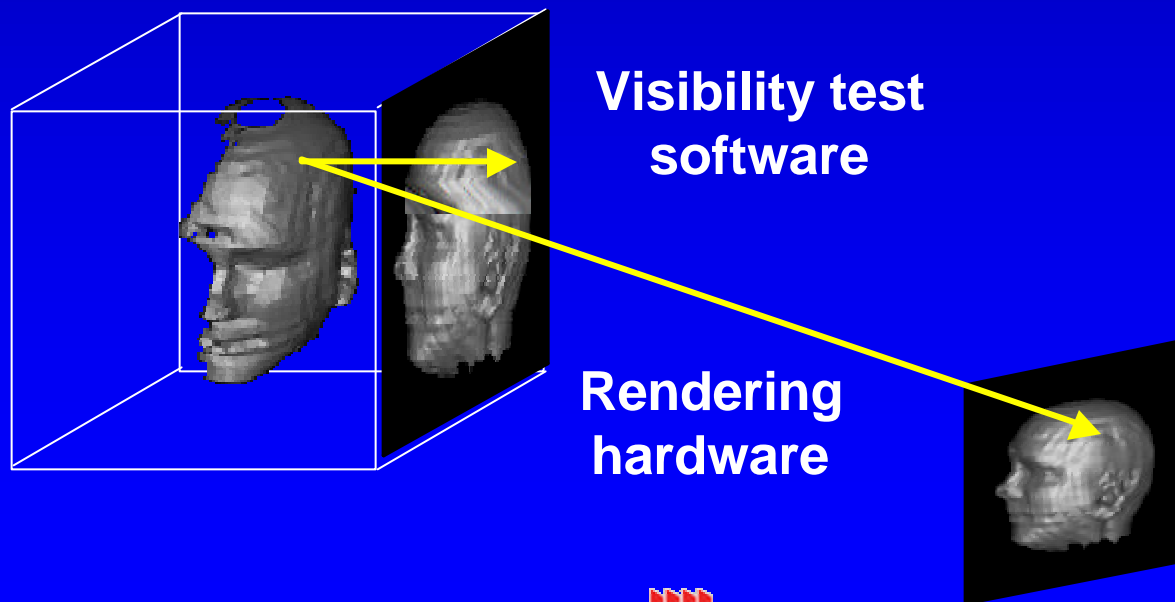- **Reduce during the search...**

View point

$O(\sqrt{k}(k))$ $O(\sqrt{k}(k))$

Pre-process $\Rightarrow$ Search ➡ construct ➡ Render ➡

Isovalue

Offline ← → ← Online →

Scalar Field Visualization

Isosurface generation

- Marching Cubes - data size
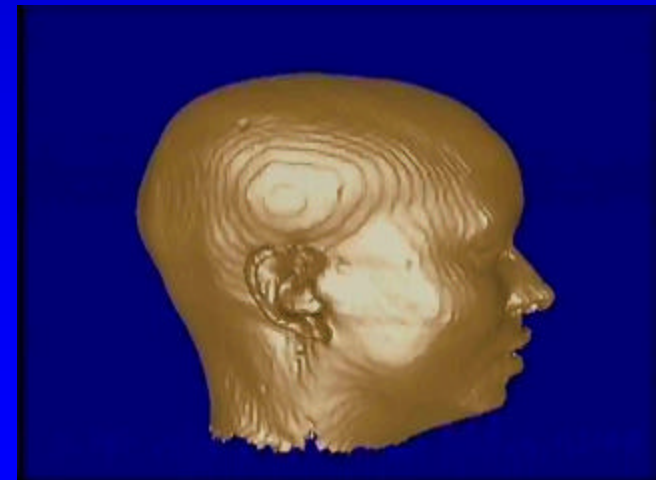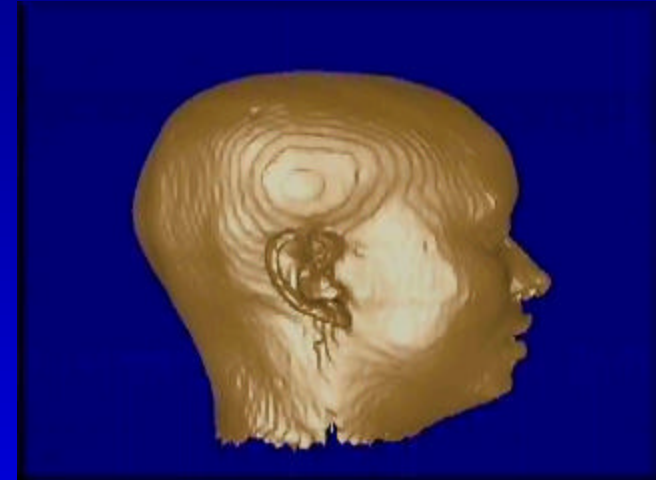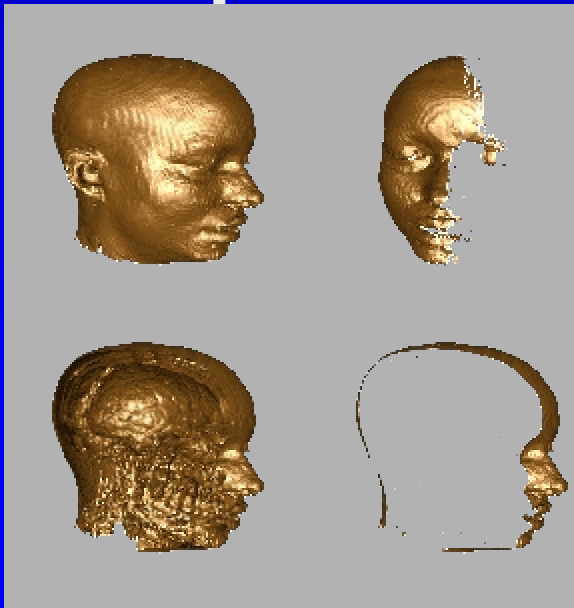- NOISE - isosurface size
- View dependent - visible portion

Visibility test
software

Rendering
hardware

A View-dependent Approach

Attractive for:

- Large datasets
- High depth complexity
- Sub-pixel

Visible Woman
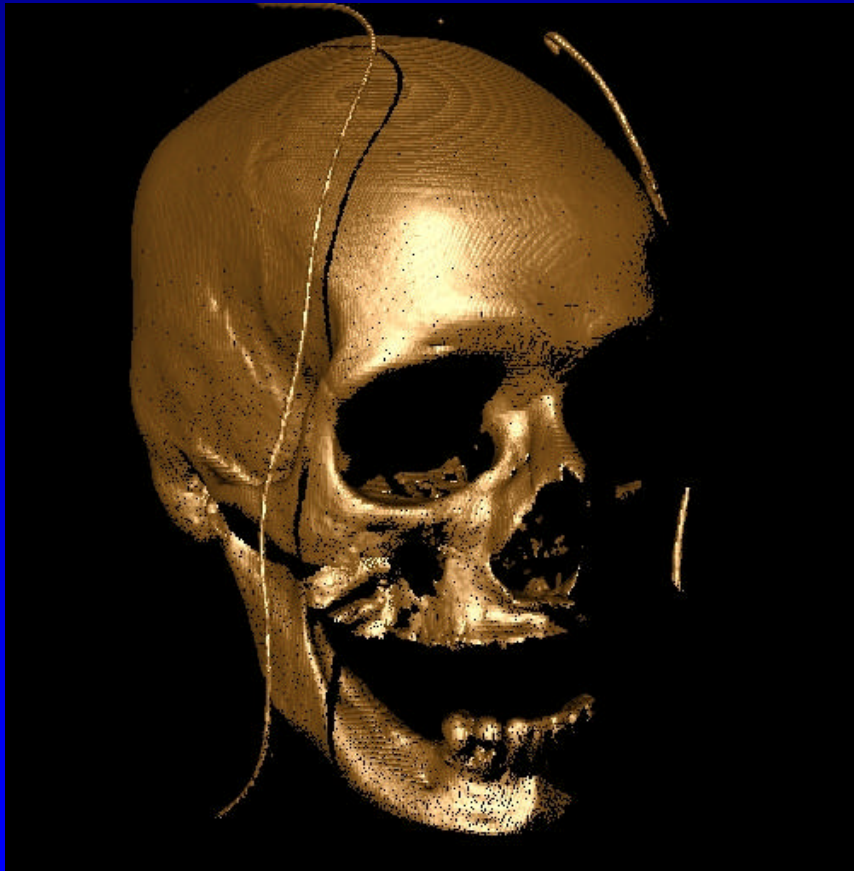
|	Full Isosurface	View depend
Polys	2,246,000	246,000
Create	177 sec	72 sec
Render	2.32 sec	0.25 sec

Real-Time Ray Tracer
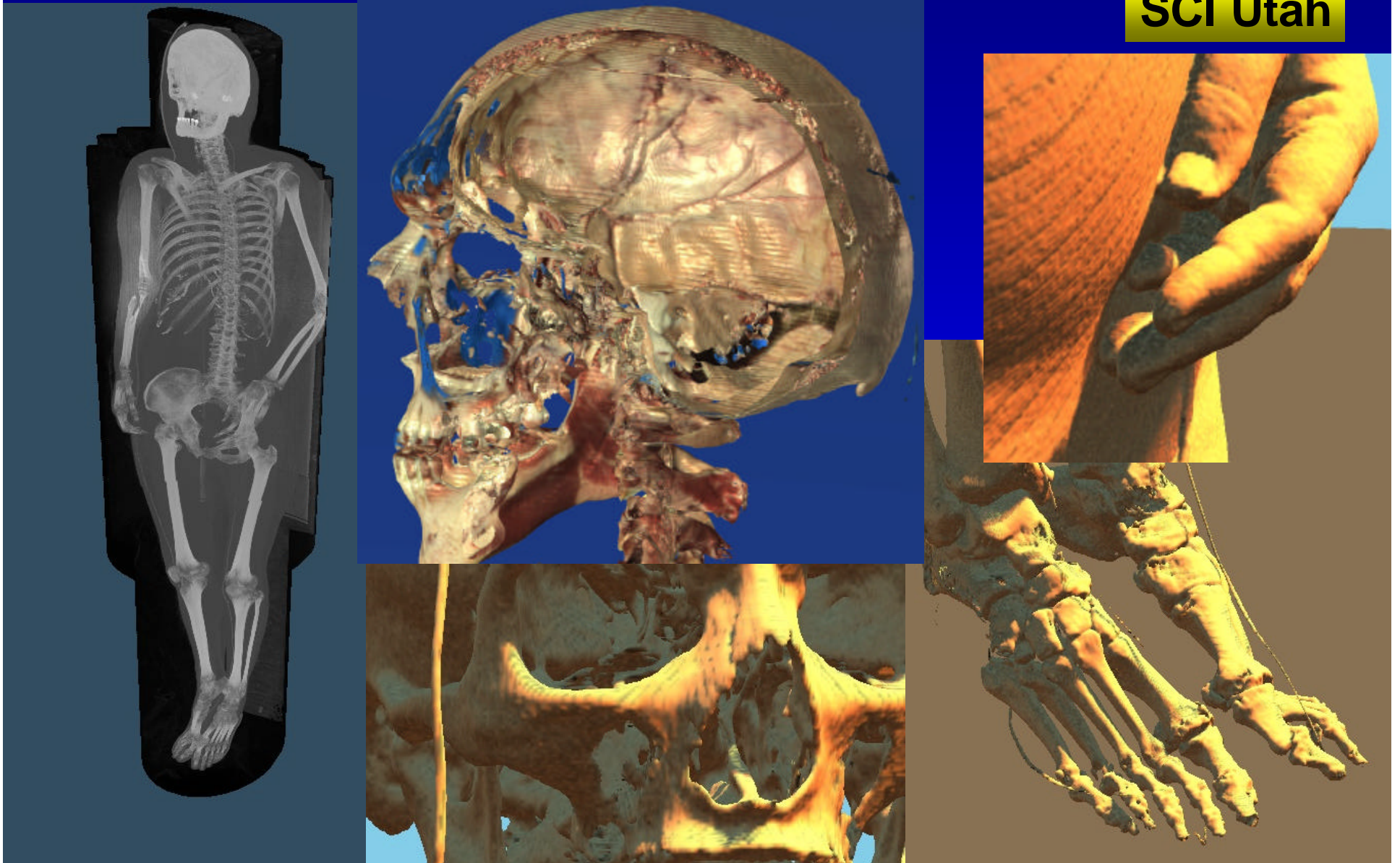
Real-Time Ray Tracer (RTRT)

Implemented on SGI Origin 2000 ccNUMA architecture - up to 128 processors (now working on a distrbuted version)

Approximately linear speedup

Load balancing and memory coherence are key to performance

Frames/second (32 processors)

20
15
10
5
0

Frame Number (time)
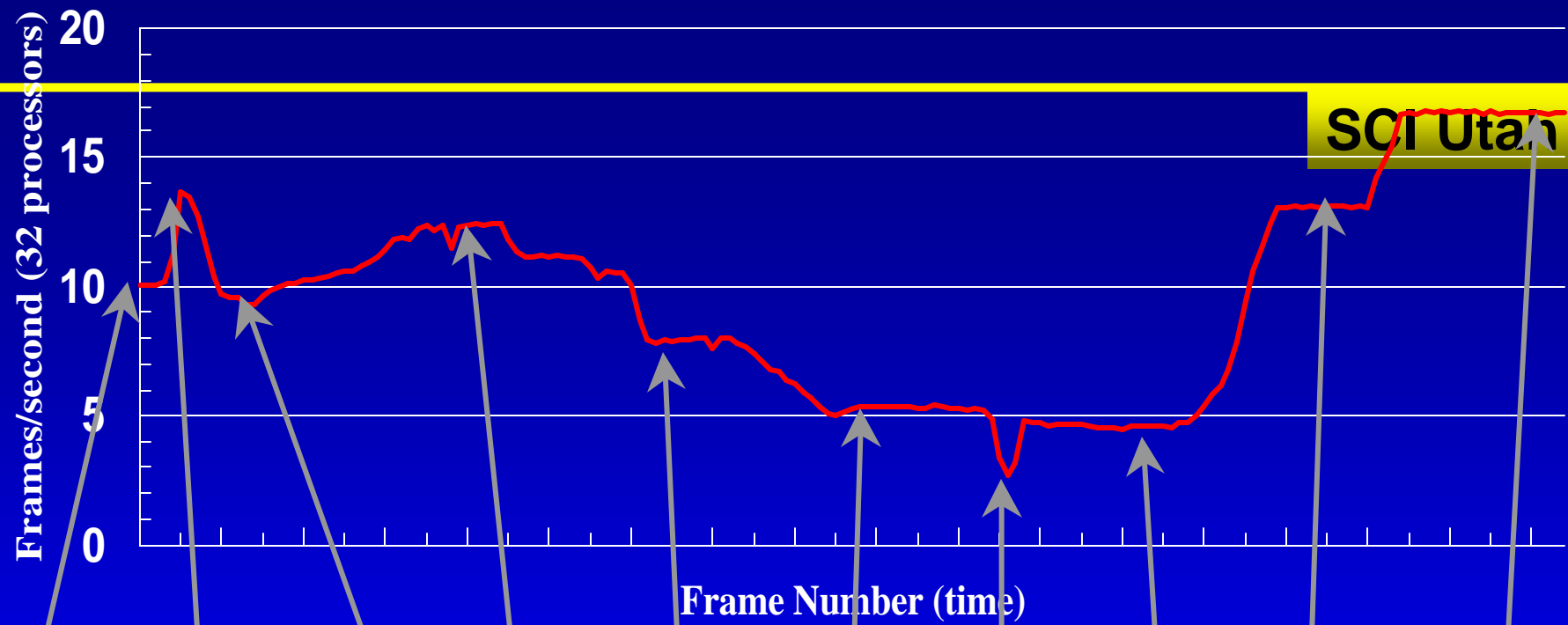
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Quantitative Visualization

Spatiotemporal Visualization (map3d)

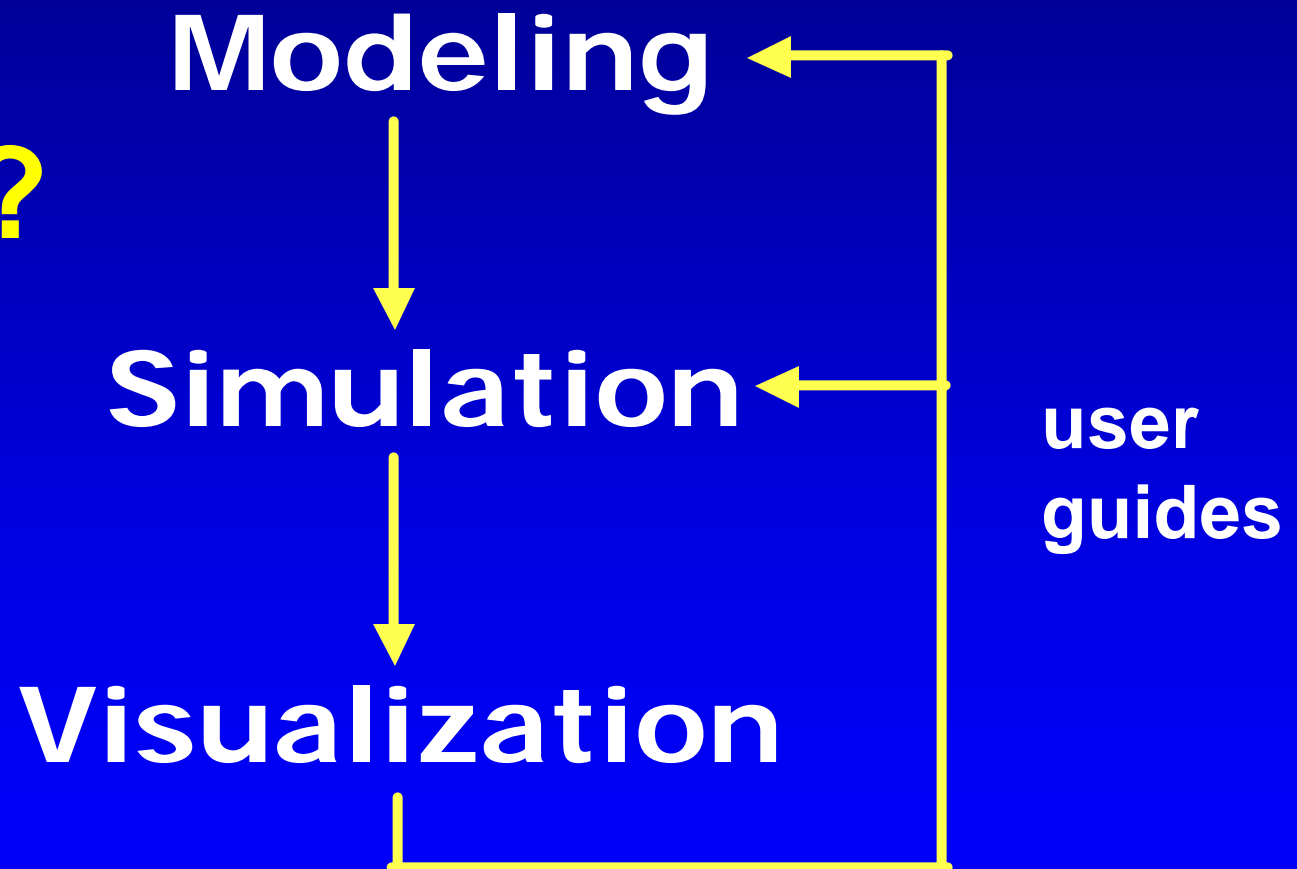Nodes & Mesh

Isocontours

Gouraud Shading

Landmarks

Scaling

Time signals
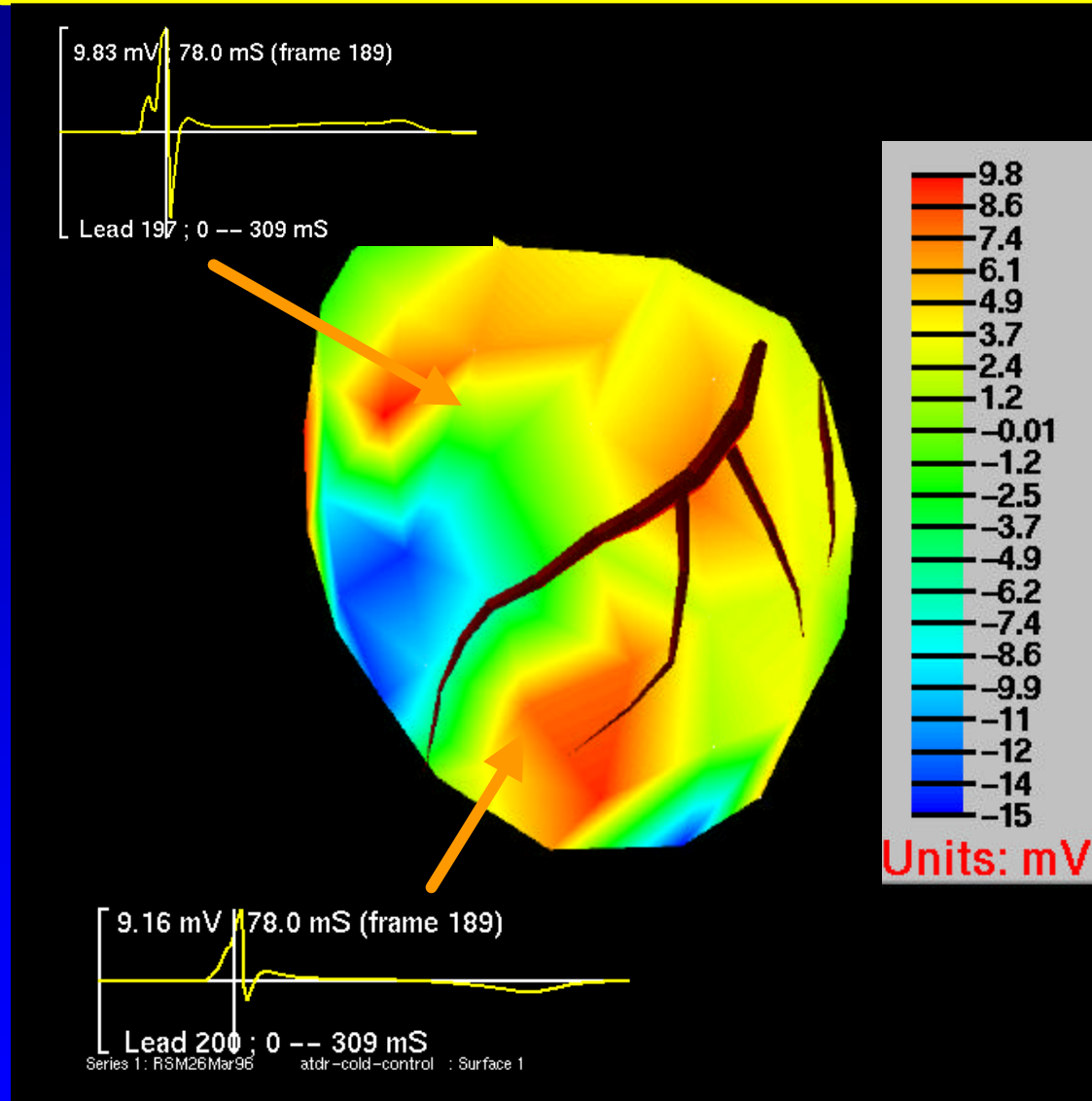
Integration and Interaction

Modeling
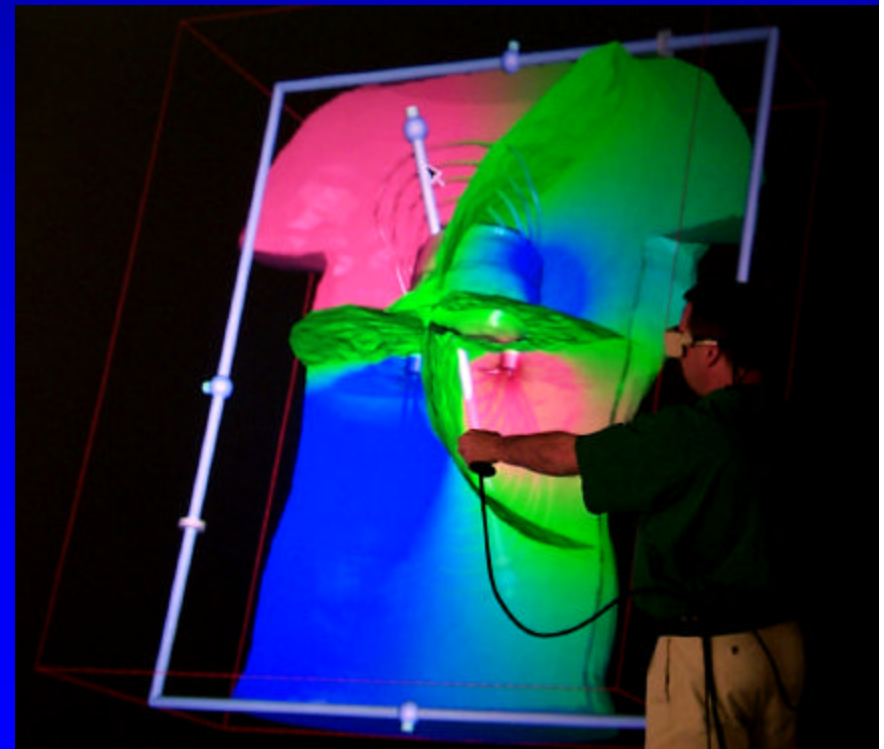
What If?

Simulation

Visualization

user guides

BioPSE – A Computational Workbench

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Common Framework for Bioelectric Field Research

- **Exchanging tools and datasets**
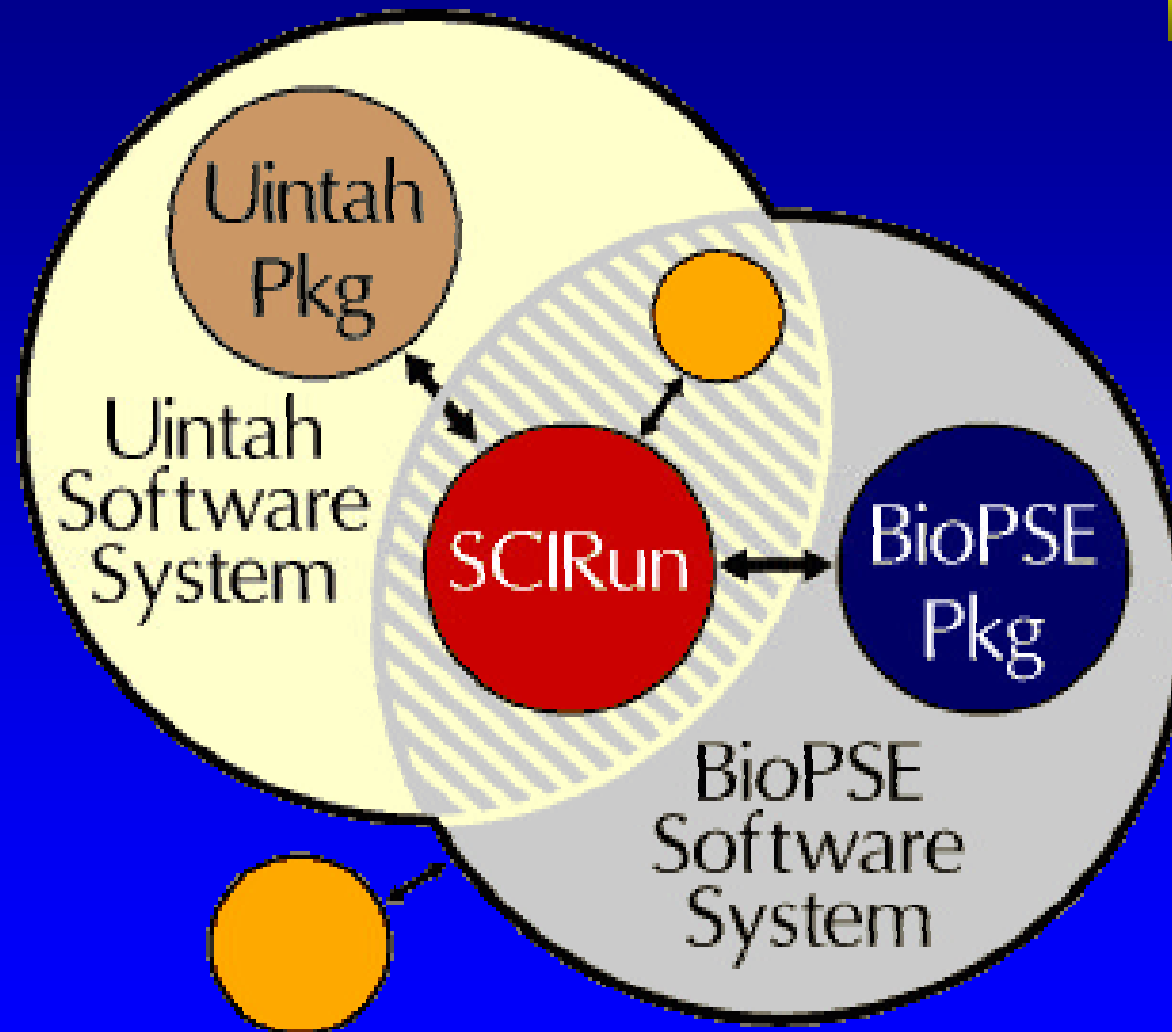- **Presenting results**
- **Comparing methods**
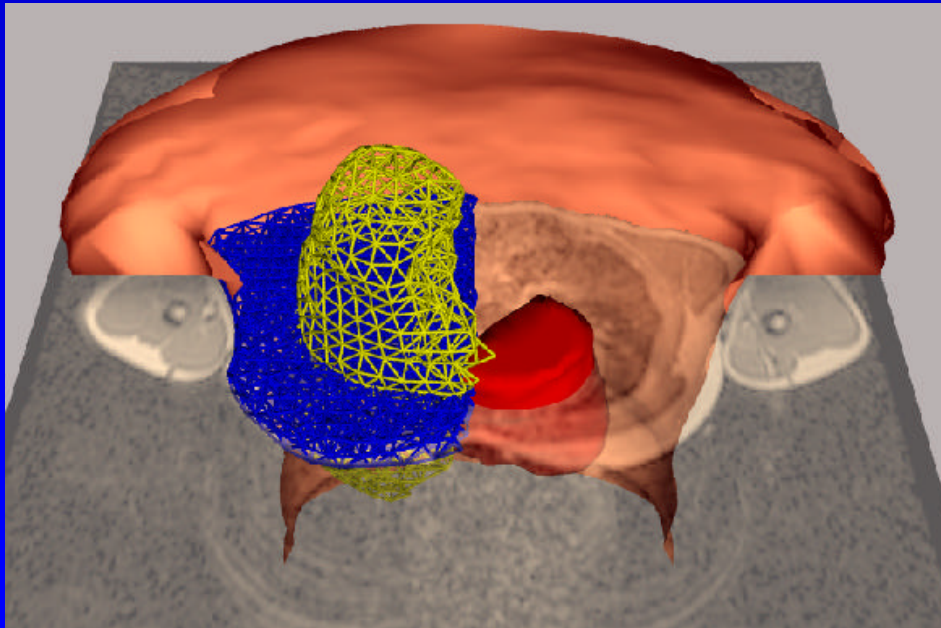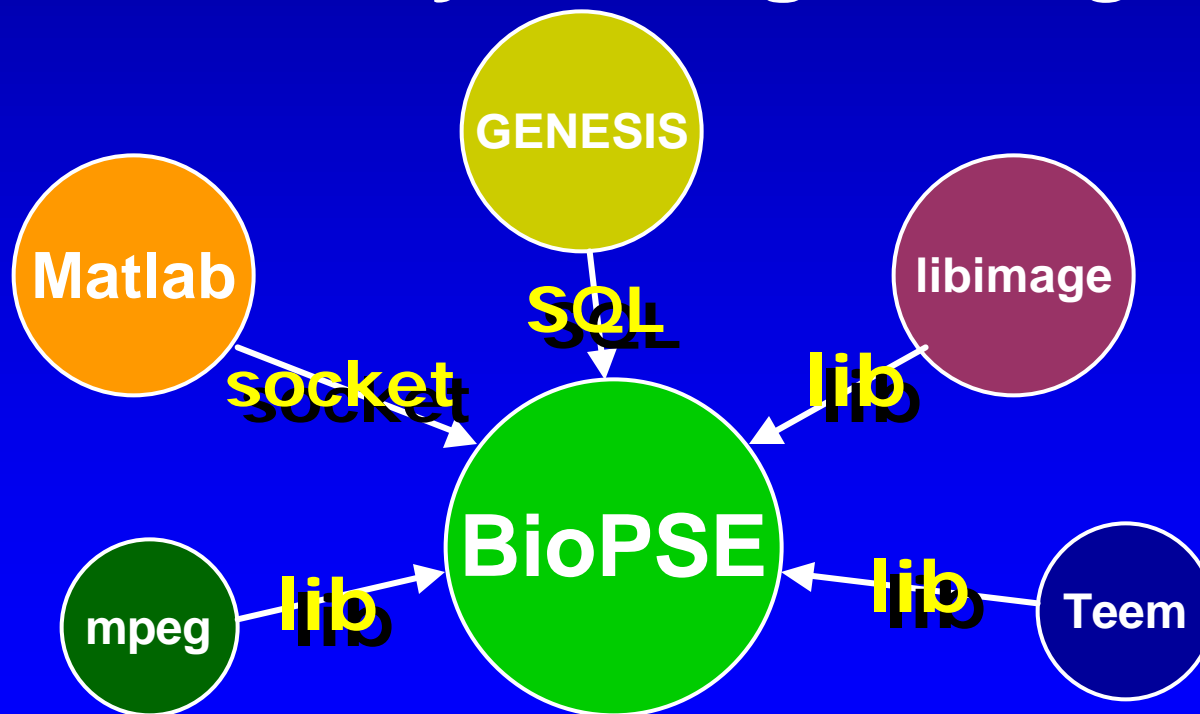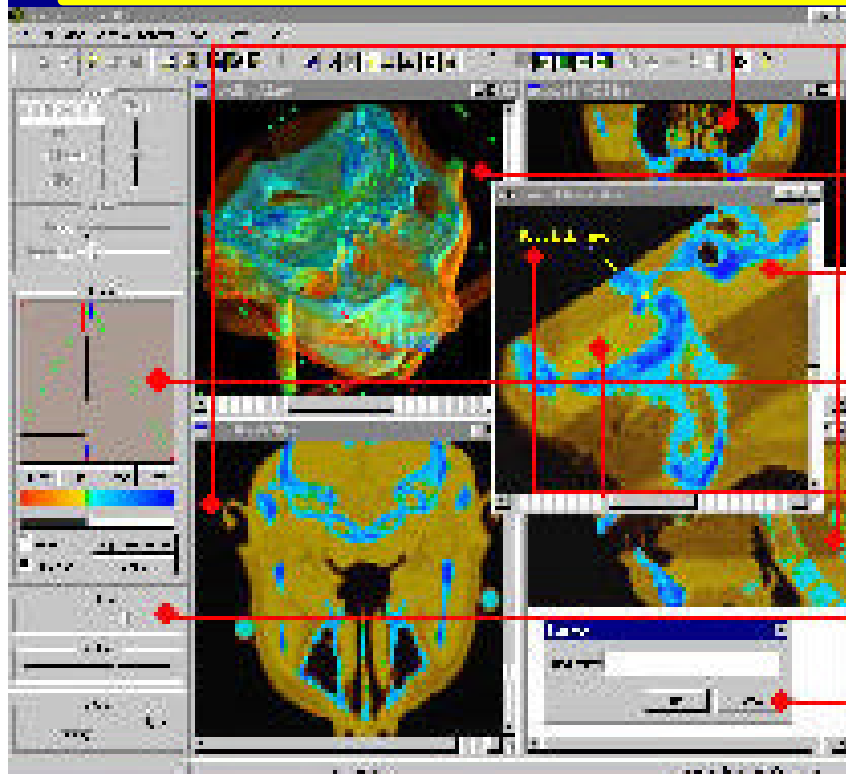
Integrated PSEs
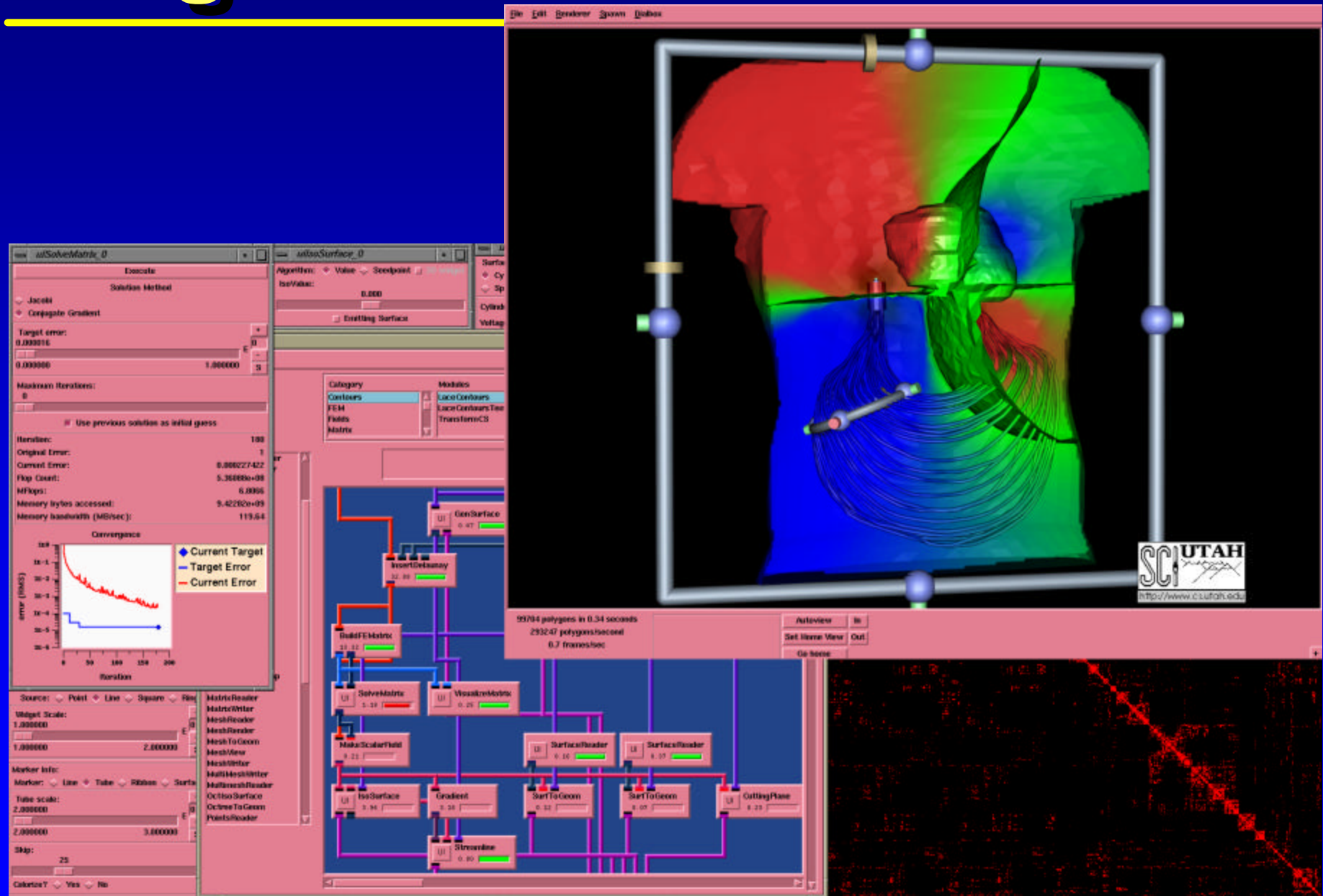
PSE Relationships

Common Architecture

- **Leverage existing utilities**
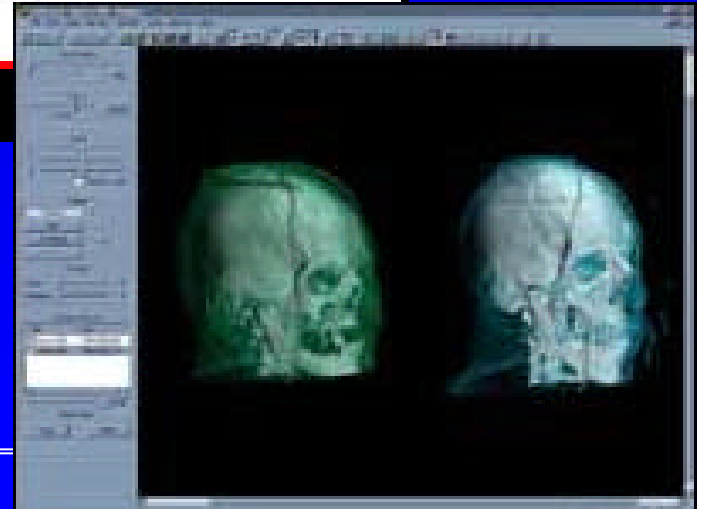- **Extensibility through *bridges***

Fraunhofer

- Synchronized Orthogonal Views
- 3D View
- Oblique Slice View
- Color Plus Alpha
- Annotation & Measurement
- Floating Pallets
- Tele-connection

User Interface

Freehand Acquisition

Stuttgart - CoVISE

UT Austin - Shastra

SCI Utah

UT Austin - Shastra

Utah

SPL - BWH

Surgical Planning Lab - BWH
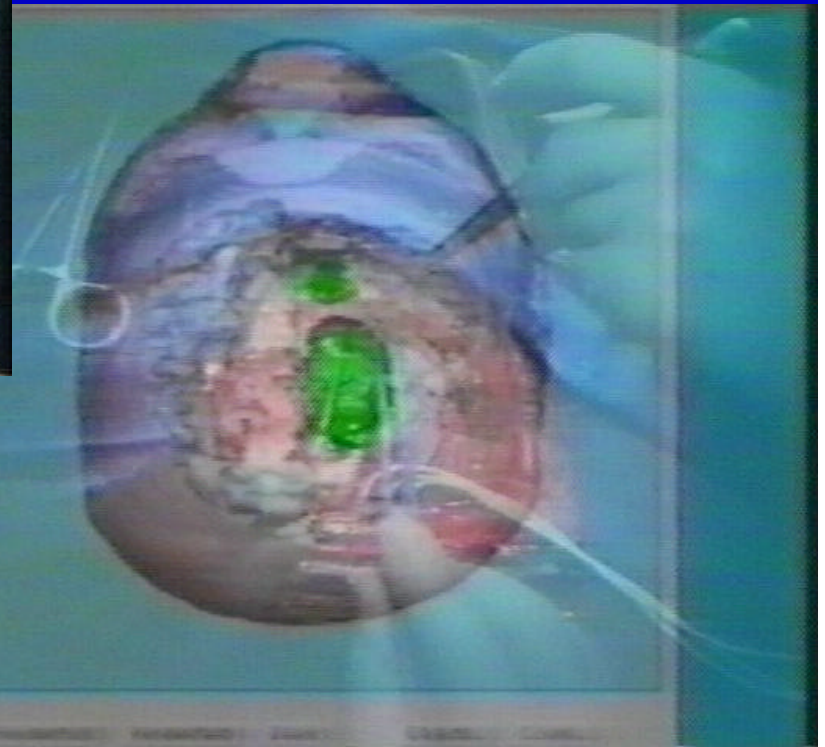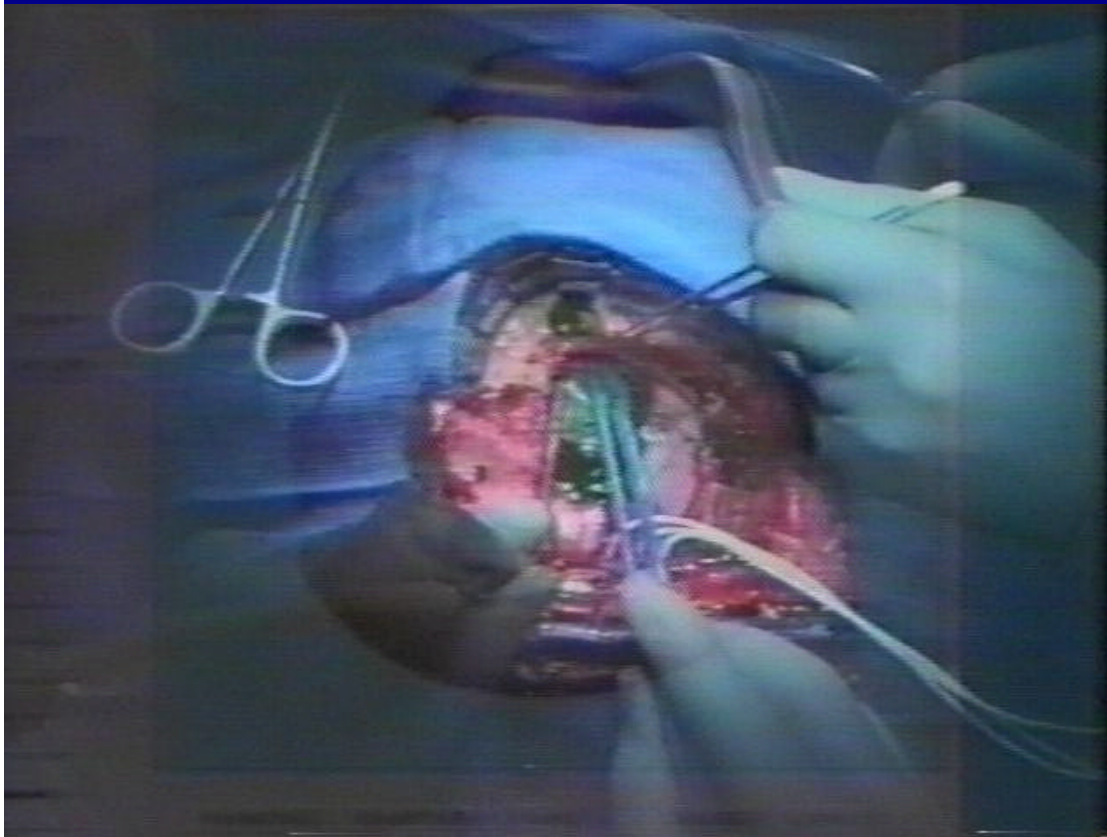
Image Overlay - CMU

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The NASA Ames Center for Bioinformatics

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Immersive Workbench
Direct Manipulation Widgets/Haptics SCI Utah

Medical Data Acquisition

Multimodal Scanning

Image Rendering

Surface Imaging — Volume Rendering

Integrated Software Environment

Intervention

Real-time Data
for Operating Room

Modeling

Finite Element Mesh

Segmentation — Registration

Data Interpretation

Error Analysis — Virtual Reality

Simulation

Inverse Imaging — Source Localization

Adaptive Pipeline

Steering Information

| 15 msec. | 5 msec. | 20 msec. | 10 msec. | 70 msec. | 15 msec. | 35 msec. |

Model Reader → A → Mesh → B → FE Modeling → C → Visualization

archival storage   *dedicated network*   *best-effort service*   *reserved bandwidth*   VR display

Computational Medicine Pipeline

Collaborative Medicine Needs

Software:

- **GUI**
- **Middleware (Gridware)**
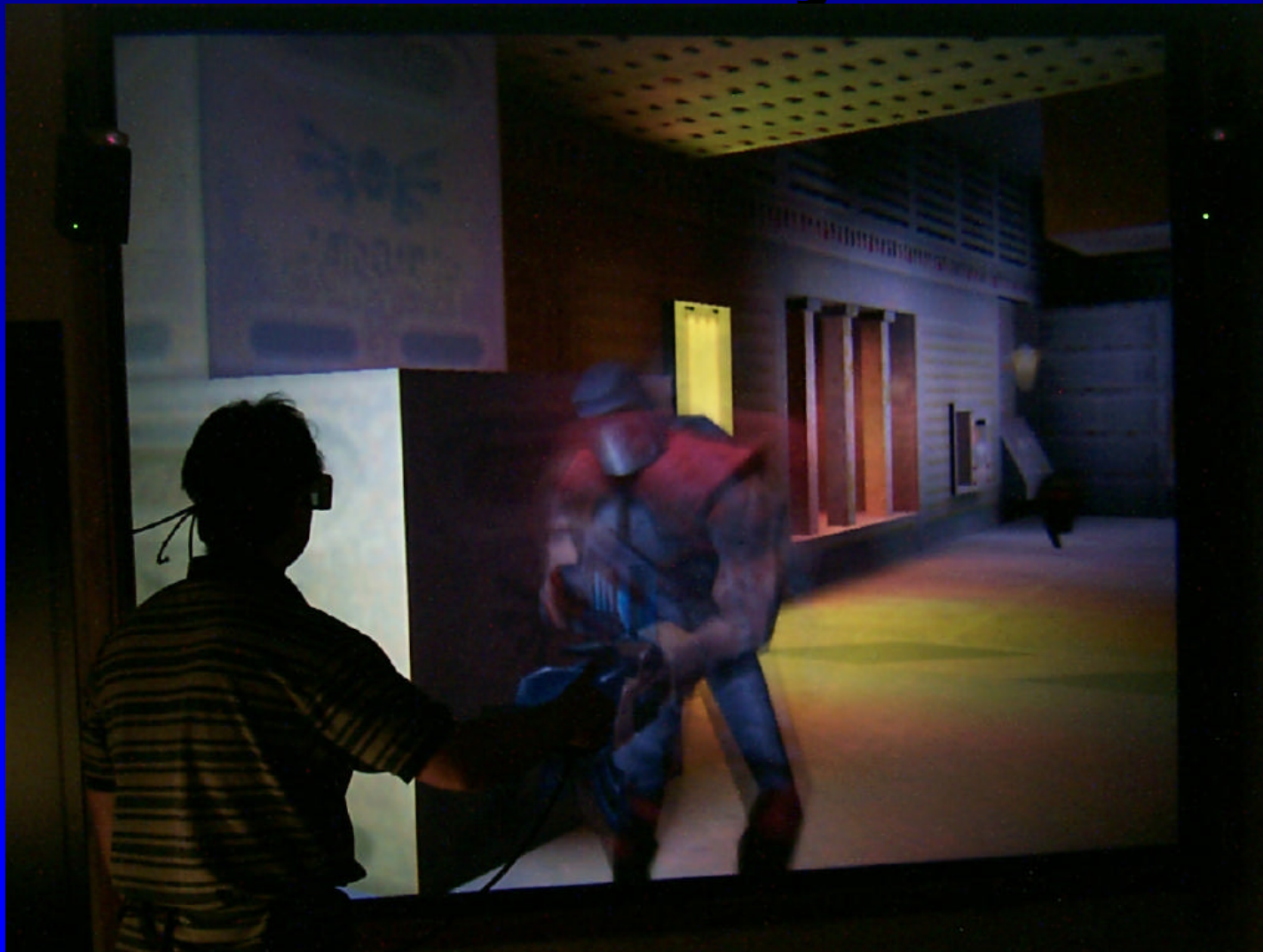- **Workflow models**
- **PSEs (Computational Workbenches)**
- **Storage resource brokering**
- **Visualization**

Distributed Video Games for 13 Year Old Boys

Scientific Computing and Imaging

Acknowledgements

DOE

NSF

NIH NCRR

DOE Computational Science
Fellowship

SGI Visual Supercomputing
Center

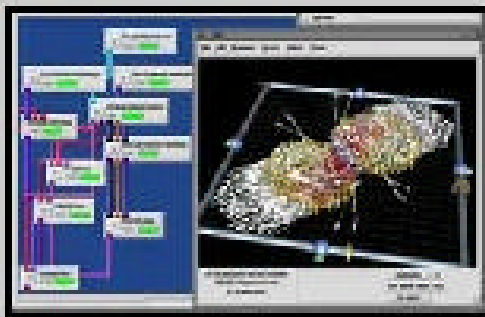Visual Influence

Software Availability

SCIRun

More Info   **Download**

For an introduction to SCIRun, see our Supercomputing '95 paper "SCIRun: A Scientific Programming Environment for Computational Steering" as well as additional information from more recent SCIRun Publications.

www.sci.utah.edu

More Information

www.sci.utah.edu

crj@cs.utah.edu